CLAIMS

WHAT IS CLAIMED IS:

1. A system for use during a medical or surgical procedure on a body, said system generating a display representing the position of one or more body elements during the procedure based on scans taken of the body by a scanner prior to the procedure, the scan having reference points for each of the body elements, the reference points of a particular body element having a known spatial relation to the particular body element, said system comprising:

means for identifying, during the procedure, the position of the reference points of each of the body elements to be displayed;

a processor modifying the image data set according to the identified position of the reference points during the procedure, as identified by the identifying means, said processor generating a displaced image data set representing the position and geometry of the body element(s) during the procedure; and

a display utilizing the displaced image data set generated by the processor, illustrating the position and geometry of the body element(s) during the procedure.

2. The system of claim 1 wherein the reference points in relation to the body elements and further comprising:

a medical or surgical instrument, probe, or radiation delivery system;

means for identifying, during the procedure, the position of medical or surgical instrument relative to one or more of the body elements; and

wherein the display is responsive to the medical or surgical instrument position identifying means

to illustrate during the procedure the relative position of the body elements relative to the medical or surgical instrument or focal point thereof.

3. The system of claim 2 wherein the medical or surgical instrument position identifying means determines an orientation of the medical or surgical instrument relative to the body elements and wherein the display illustrates the orientation of the medical or surgical instrument relative to the body elements.

4. The system of claim 1 wherein the identifying means comprises:

a reference array having a location outside the body for providing a reference; and

means for determining the position of the reference points of the body elements to be displayed relative to the reference array.

5. The system of claim 4 further comprising a registration probe in communication with the reference array and wherein the determining means is adapted to determine the position of a tip of the registration probe relative to the reference array whereby the position of the reference points of the body elements can be determined by positioning the tip of the registration probe at each of the reference points.

6. The system of claim 5 wherein the reference array includes sensors and wherein the registration probe includes emitters communicating with the sensors of the reference array to indicate the position of the registration probe relative to the reference array.

7. The system of claim 5 wherein the registration probe includes sensors and wherein the

reference array includes emitters communicating with the sensors of the registration probe to indicate the position of the registration probe relative to the reference array.

8. The system of claim 4 further comprising a reference frame having a position in known relation to one of the body elements, said reference frame in communication with the reference array, and further comprising means for determining the position of the reference frame relative to the reference array whereby the body may be moved during the procedure while the body elements remain in fixed relation to each other and in known relation to the reference frame so that the system can determine the position of each of the body elements after movement without again identifying the relative position of each of the reference points of each of the body elements.

9. The system of claim 8 wherein the reference array includes sensors and wherein the reference frame is attached to one of the body elements and includes emitters communicating with the sensors of the reference array to indicate the position of the reference frame relative to the reference array.

10. The system of claim 8 wherein the reference frame includes sensors and wherein the reference array is attached to one of the body elements and includes emitters communicating with the sensors of the reference frame to indicate the position of the reference frame relative to the reference array.

11. The system of claim 1 further comprising means for discriminating the body elements of the image

data set by creating an image data subset defining each of the body elements.

12. The system of claim 11 wherein the processor translates each of the image data subsets from the position of the body elements prior to the procedure to the position of the body elements during the procedure whereby the displaced data set consists of the translated image data subsets.

13. The system of claim 11 wherein the identifying means comprises a device for determining a position of a contour of each of the body elements during the procedure and wherein the processor compares the position of the contour of each of the body elements during the procedure as determined by the device to the position of the contour of each of the body elements prior to the procedure as represented by the image data sub-set.

14. The system of claim 13 wherein the identifying means comprises an ultrasound probe for determining a position of a contour of each of the body elements during the procedure and wherein the processor compares the position of the contour of the each of the body elements during the procedure as determined by the device to the position of the contour of each of the body elements prior to the procedure as represented by the image data subset whereby the contour of the body elements may be determined without the need for exposing the body elements.

15. The system of claim 13 wherein the identifying means comprises a scanner for determining a position of a contour of each of the body elements during the procedure and wherein the processor compares the

position of the contour of the each of the body elements during the procedure as determined by the device to the position of the contour of each of the body elements prior to the procedure as represented by the image data subset.

16. The system of claim 14 wherein said ultrasound probe has emitters thereon in communication with the reference array and wherein the determining means is adapted to determine the position of the ultrasound probe relative to the reference array whereby the position of the contour of each body element can be determined.

17. The system of claim 14 wherein said reference array has emitters thereon in communication with the ultrasound probe and wherein the determining means is adapted to determine the position of the ultrasound probe relative to the reference array whereby the position of the contour of each body element can be determined.

18. The system of claim 15 wherein said scanner has emitters thereon in communication with the reference array and wherein the determining means is adapted to determine the position of the scanner relative to the reference array whereby the position of the contour of each body element can be determined.

19. The system of claim 15 wherein said reference array has emitters thereon in communication with the scanner and wherein the determining means is adapted to determine the position of the scanner relative to the reference array whereby the position of the contour of each body element can be determined.

20. The system of claim 4 wherein the identifying means comprises a fluoroscopic device for determining a position of a projection of each of the body elements during the procedure and wherein the processor compares the position of the projection of the each of the body elements during the procedure to the position of the projection of each of the body elements prior to the procedure.

21. The system of claim 20 wherein the fluoroscopic device comprises a fluoroscopic tube in fixed relation to a fluoroscopic plate between which the body elements are located for determining a position of a projection of each of the body elements during the procedure and wherein the processor compares the position of the projection of each of the body elements during the procedure to the position of the projection of each of the body elements prior to the procedure.

22. The system of claim 21 wherein said fluoroscopic tube or said fluoroscopic plate each have emitters thereon in communication with the reference array and wherein the determining means is adapted to determine the position of the tube and plate relative to the reference array whereby the position of the projection of each body element can be determined.

23. The system of claim 21 wherein said reference array has emitters thereon in communication with the fluoroscopic tube or the fluoroscopic plate and wherein the determining means is adapted to determine the position of the tube or plate relative to the reference array whereby the position of the projection of each body element can be determined.

24. A method for use during a procedure, said method generating a display representing the position of two or more body elements during the procedure based on an image data set generated prior to the procedure, which image data set has reference points for each of the body elements, said method comprising the steps of:

identifying, during the procedure, the relative position of each of the reference points of each of the body elements to be displayed;

modifying the image data set according to the identified relative position of each of the reference points during the procedure in order to generate a displaced image data set representing the position of the body elements during the procedure; and

generating a display based on the displaced image data set illustrating the relative position of the body elements during the procedure.

25. The method of claim 24 further comprising the step of repositioning the body elements so that the display based on the displaced data set representing the position of the body elements during the procedure is substantially the same as the display based on the image data set generated prior to the procedure whereby the position of the body elements after repositioning is substantially the same as the position of the body elements prior to the procedure when the image data set was generated.

26. The method of claim 24 wherein the reference points are part of the body elements and further comprising the steps of:

providing a medical or surgical instrument;

identifying, during the procedure, the position of medical or surgical instrument relative to one or more of the body elements; and

generating a display based on the position of the medical or surgical instrument illustrating the relative position of the body elements and the medical or surgical instrument during the procedure.

27. The method of claim 26 further comprising the steps of determining an orientation of the medical or surgical instrument relative to the body elements and generating a display illustrating the orientation of the medical or surgical instrument relative to the body elements.

28. The method of claim 24 further comprising the steps of:

providing a reference array having a location outside the body for providing a reference; and

determining the position of the reference points of the body elements to be displayed relative to the reference array.

29. The method of claim 28 further comprising the steps of providing a registration probe in communication with the reference array and determining the position of the reference points of the body elements by positioning the tip of the registration probe at each of the reference points.

30. The method of claim 28 further comprising the steps of providing a reference frame having a position in fixed relation to one of the body elements, said reference frame in communication with the reference array, and determining the position of the reference frame relative to the reference array whereby the body may be moved during the procedure while the body elements remain in fixed relation to each other and the reference frame so that the method can determine the position of

each of the body elements after movement without again identifying the relative position of each of the reference points of each of the body elements.

31. The method of claim 24 further comprising the step of discriminating the body elements of the image data set by creating an image data subset defining each of the body elements.

32. The method of claim 31 further comprising the step of translating each of the image data subsets from the position of the body elements prior to the procedure to the position of the body elements during the procedure whereby the displaced data set comprises the translated image data subsets.

33. The method of claim 31 comprising the steps of determining a position of a contour of each of the body elements during the procedure and comparing the position of the contour of the each of the body elements during the procedure to the position of the contour of each of the body elements prior to the procedure as represented by the image data set.

34. The method of claim 24 wherein the identifying step comprises the steps of positioning the body elements between a fluoroscopic tube and a fluoroscope plate in fixed relation to the tube, energizing the tube to generate a projection of each of the elements on the plate, determining the relative position of the fluoroscopic projection of each of the body elements during the procedure and comparing the position represented by the fluoroscopic projection of each of the body elements during the procedure to the relative position of the body elements prior to the procedure.

35. A method for use with two or more body elements which each have reference points, said method comprising the steps of:

prior to a procedure:

placing the body elements in a frame to fix their relative position; and

scanning the fixed body elements; and

during the procedure:

placing the body elements in the frame so that the body elements have the same relative position as their position during scanning;

determining the position of reference points on the body elements relative to reference means;

determining the position of a medical or surgical instrument relative to the reference means;

determining the position of the medical or surgical instrument relative to the body elements; and

generating a display based on the pre-procedural scanning illustrating the determined position of the medical or surgical instrument relative to the body elements.

36. The method of claim 35 wherein the frame can be activated to move the body elements and further comprising the steps of determining the relative position of the body elements during the procedure and activating the frame to move the body elements so that the relative position of the body elements during the procedure corresponds to the relative position of the body elements during the scan prior to the procedure.

37. The system of claim 8 wherein the reference array includes sensors and wherein the reference frame is comprised of a device which is capable of continuously or periodically detecting and tracking one or more of the body elements and includes emitters

communicating with the sensors of the reference array to indicate the position of the reference frame relative to the reference array.

38. The system of claim 11 wherein the processor transforms each of the image data subsets representing the position and shape of the body elements prior to the procedure to represent the position and shape of the body elements during the procedure whereby the displaced data set consists of the transformed image data subsets.

39. The system of claim 2 wherein the processor monitors the position of the instrument, probe or radiation delivery system and deactivates it when the monitored position indicates that it is outside a predefined safe zone.

40. The system of claim 2 further comprising robotics to control the position of the instrument, probe or radiation delivery system and wherein the processor would monitor the position of the instrument and instruct the robotics to control it in a predetermined manner.

41. A device for use with a surgical navigation system having a sensor array which is in communication with the device to identify its position, said device comprising:

a base member having a cavity therein;

a plurality of light emitting diodes on the base member, said diodes emitting light, when activated, for communicating with the sensor array of the surgical navigation system;

an activating circuit connected to the diodes for providing signals for activating the diodes; and

wires located in the cavity of the base member and electrically interconnecting the power supply and the light emitting diodes and for transmitting the signals for activating the diodes.

42. A device for use with a surgical navigation system having a sensor array which is in communication with the device to identify its position, the device for engaging a structure attached to or an instrument in known relation to a body part thereby providing a known reference relative to the body part, the device having a connector for engaging a cable connected to the surgical navigation system, the cable for providing signals for activating the device, said device comprising:

a base member having a cavity therein;

a coupling on the base member for engaging the structure in order to maintain the base member in fixed relation to the body part thereby providing the fixed reference;

a plurality of light emitting diodes on the base member, said diodes, when activated, emitting light for communicating with the sensor array of the surgical navigation system;

a connector attached to the base member and adapted to engage the cable connected to the surgical navigation system, said connector for receiving the signals for activating the diodes; and

wires located in the cavity of the base member and electrically interconnecting the connector and the light emitting diodes and for transmitting the signals received by the connector to the diodes to activate the diodes.

43. The device of claim 42 wherein the base member comprises an arc-shaped member and wherein the

coupling comprises a fitting for engaging a head-clamp such as a Mayfield clamp adapted to engage a head of a patient.

44. The device of claim 43 further comprising spring clamps on the arc-shaped member for engaging a retractor arm for engaging the head and assisting in a surgical or medical procedure to be performed on the head.

45. The device of claim 42 for engaging a thoraco-lumbar mount adapted to engage a spinal bone of a patient wherein the base member comprises a generally U-shaped member and wherein the coupling comprises a variable position connector for engaging the thoraco-lumbar mount so that the U-shaped member can be positioned to form various angles relative to the mount.

46. A device for use with a surgical navigation system having a sensor array which is in communication with the device to identify its position, the device for guiding an instrument for engaging a body part thereby locating the instrument at a known position relative to the body part, the device having a connector for engaging a cable connected to the surgical navigation system, the cable for providing signals for activating the device, said device comprising:

a housing having a cavity therein;

a structure on the housing for guiding the instrument in order to maintain the instrument in a relationship relative to the housing;

a plurality of light emitting diodes on the housing, said diodes, when activated, emitting light for communicating with the sensor array of the surgical navigation system;

a connector attached to the housing and adapted to engage the cable connected to the surgical navigation system, said connector for receiving the signals for activating the diodes; and

wires located in the cavity of the housing and electrically interconnecting the connector and the light emitting diodes and for transmitting the signals received by the connector to the diodes to activate the diodes.

47. The device of claim 46 further comprising a guide tube mounted on the housing for receiving a biopsy instrument and a support member projecting from the housing for engaging a clamp which maintains the housing in a relatively fixed position.

48. The device of claim 46 further comprising a handle attached to the housing and a guide member having a opening therein for receiving a drill bit.

49. The device of claim 46 further comprising a yoke attached to the housing and having a opening therein for receiving a drill bit.

50. The device of claim 46 further comprising a guide tube attached to the housing and having a opening therein for receiving a catheter.

51. The device of claim 46 further comprising a depression in the housing for receiving a probe used in combination with the surgical navigation system for calibrating the system and the device.

52. A device for use with a surgical navigation system having a sensor array which is in communication with the device to identify its position, the device for use in guiding a catheter, the device for

engaging a cable connected to the surgical navigation system, the cable for providing signals for activating the device, said device comprising:

a handle having a cavity therein;

a plurality of light emitting diodes on the handle, said diodes emitting light, when activated, for communicating with the sensor array of the surgical navigation system;

a connector attached to the handle and adapted to engage the cable connected to the surgical navigation system, said connector for receiving the signals for activating the diodes;

wires located in the cavity of the handle and electrically interconnecting the connector and the light emitting diodes and for transmitting the signals received by the connector to the diodes; and

a guide member connected to the handle for guiding the catheter.

53. A surgical navigation system comprising:

a controller;

a sensor array;

a reference frame in communication with the array to identify its position; and

a localization frame in communication with the array to identify a position of the localization frame, the localization frame for guiding the instrument for engaging the body part thereby locating the instrument at a known position relative to the body part, the localization frame connected to the controller which provides signals for activating the localization frame.

54. The system of claim 53 wherein the reference frame comprises:

a base member having a cavity therein;

a plurality of light emitting diodes on the base member, said diodes emitting light, when activated, for communicating with the sensor array of the surgical navigation system;

an activating circuit connected to the diodes for providing signals for activating the diodes; and

wires located in the cavity of the base member and electrically interconnecting the power supply and the light emitting diodes and for transmitting the signals for activating the diodes.

55. The system of claim 53 wherein the localization frame comprises:

a housing having a cavity therein;

a structure on the housing for guiding the instrument in order to maintain the instrument in a relationship relative to the housing;

a plurality of light emitting diodes on the housing, said diodes, when activated, emitting light for communicating with the sensor array of the surgical navigation system;

a connector attached to the housing and adapted to engage the cable connected to the surgical navigation system, said connector for receiving the signals for activating the diodes; and

wires located in the cavity of the housing and electrically interconnecting the connector and the light emitting diodes and for transmitting the signals received by the connector to the diodes to activate the diodes.

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